RESEARCH REPORT

Risk factors for asthma prevalence and chronic respiratory illnesses among residents of different neighbourhoods in Buffalo, New York

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Study objective: The aim of this study is to identify risk factors for asthma prevalence and chronic respiratory illnesses in Buffalo's neighbourhoods after previous studies reported increased levels of asthma among residents on Buffalo's west side.
Design: Cross sectional surveys.
Setting: Buffalo neighbourhoods along a US-Canada border crossing point.
Subjects: A systematic random survey of 82% of the 2000 targeted households was conducted between January and August 2002.
Main results: A multivariate logistic regression model shows that the risk of persons with asthma and chronic respiratory illnesses is significantly ($p \leqslant 0.05$) high among children and young adults living in Buffalo's west side, newer housing units, and of Latino ethnicity. In a separate analysis of the nine risk factors, it was observed that location, gender, age, and race were significant risk factors even after adjusting for age of housing, pets, moulds, animal trigger, and smoking.
Conclusions: These findings confirm the hypothesis that a considerable risk of asthma and chronic respiratory illnesses exists particularly among Buffalo's west side residents. Further evaluation of these risk factors is warranted to determine the severity of asthma and the reasons for such a significant disease burden.

Increased risk of asthma and chronic respiratory illnesses has been the main focus of several studies[1–12] conducted along the US-Canada border crossing point. The studies have found increased asthma and chronic respiratory illnesses among communities living near frequently travelled highways, the US Environmental Protection Agency (EPA) designated pollution source sites, and in close proximity to the US-Canada border crossing on Buffalo's west side.

While the exact causes of increased asthma prevalence and healthcare utilisation rates are still unknown, lower socioeconomic status,[7] and four suspected indoor and outdoor exposure factors seem to contribute to the severity of asthma among Buffalo, New York communities. Geographical studies[3–6 8 9 11 12] suggest that traffic related pollution is a potential factor. There are also EPA designated pollution sites[12] that contribute to the asthma risk. Oyana and coworkers in that previous report found that asthma risk increased as distance from the exposure sites decreased. Two house to house surveys, conducted six years apart,[7 13] have also suggested that home environmental factors (triggers), including smoking, humidifiers, and age of housing units were associated with increased asthma prevalence rates. A separate analysis of socioeconomic factors[4 7] found that asthma prevalence varies by race and gender, even after adjusting for confounding variables.

A recent report focused on the traffic related ultrafine particulate pollutants[10] as potential contributors to differences in asthma prevalence rates among Buffalo's neighbourhoods.[13] Traffic related pollution at border crossings is currently receiving greater attention for two important reasons: (1) implementation of the North American Free Trade Agreement (NAFTA) has resulted in greater increase in diesel burning commercial traffic[14]; and (2) implementation of stricter border inspection procedures has resulted in extensive waiting times for traffic and has a potential for increasing traffic related pollution independent of traffic volumes.[15] Asthma and respiratory symptoms can be worsened by increases in levels of traffic related pollution.[16–27]

While these studies have shed some light about asthma prevalence and morbidity among residents living in this border region, little information presently exists on the role of risk factors. Interest in the subject of risk factors has been fuelled by lack of a clear understanding of why certain Buffalo neighbourhoods are more affected than others. In this study, we analyse the relative contributions of risk factors and identify which of these factors might have a significant contribution in the prevalence and exacerbations of asthma and chronic respiratory illnesses. It is hypothesised that a considerable risk of asthma and chronic respiratory illnesses exists among certain groups living in specified locations of the study area.

METHODS

The study was based on a cross sectional survey of a systematic random sample of 2000 households located in the City of Buffalo. The study was implemented in five geographical regions identified in Buffalo, New York, using a standardised three part questionnaire that was administered to the head of each household. A study protocol was developed to simultaneously assess disease prevalence and possible exposure to United States EPA identified pollution release sources (later referred to as potential exposure sites) among residents in the neighbourhoods. Based on the 2000 census figures, 121 954 households were located in the study area. We targeted more than 1.6% of the total number of households in the study area. Households were visited during

Abbreviations: EPA, Environment Protection Agency; NAFTA, North American Free Trade Agreement; CAEE, Centre for Asthma and Environment Exposure

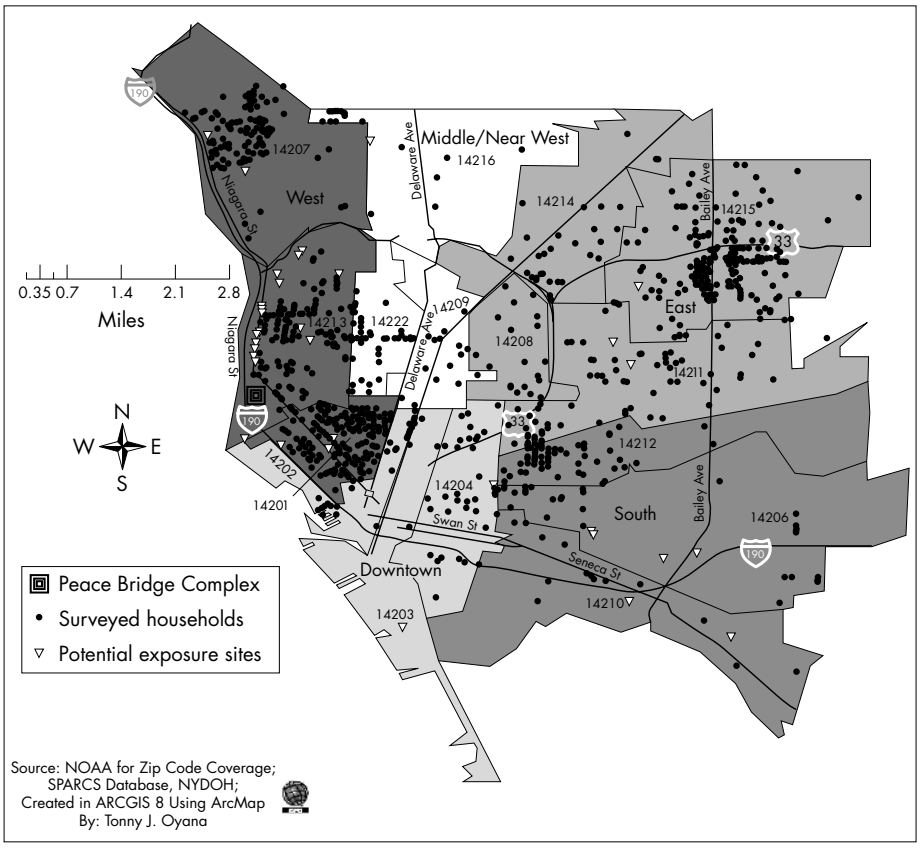

Figure 1 Spatial distribution of surveyed households according to geographical regions in relation to major roadways and potential exposure sites.

an eight month period starting from 1 January 2002 to the end of August 2002, primarily in the mornings and evenings on weekdays and on weekends after 1 pm. This study was approved by the University at Buffalo Human Investigation Committee in accordance with national and institutional guidelines for the protection of human subjects. All participants signed a statement of informed consent.

The survey was conducted using 17 trained community residents (35 were recruited but a rigorous selection procedure left 17) who had previously completed a 2.5 hour training session given by the Centre for Asthma and Environmental Exposure (CAEE) staff. Additional training in quality control measures and error handling procedures was provided to team leaders of each group. The surveyors had no prior knowledge of asthma prevalence among the households surveyed.

In the field, a sample selection was determined through a four stage process. The first stage entailed establishing the actual size and geographical distribution of households in the study area using current postal data. A spreadsheet of households was created in MS Excel (Microsoft, Seattle, WA). We then randomly (using a random integer between 1 and 60) selected the first household. We prepared a short list for the surveyors showing every fourth household organised by block starting from the 36th household. The surveyors were then asked to administer a questionnaire to every fourth household or to the nearest households whenever they found unoccupied houses, or if a respondent in the household

Table 1 List of variables (risk factors) used in multivariate analysis

Variable	Association	Variable	Association
Eastside		Other pets	
Westside	+	Moulds	
South Buffalo		Cockroaches	
Near west		Mice	
Downtown		Smoke	
Male	−	Education<high school	
Female		Education>high school	
Age of housing (dwellings) 1–24 years	+	Age 1–5 years	
Age of housing (dwellings) 24–54 years		Age 6–17 years	+
Age of housing (dwellings) 55–99 years		Age 18–34 years	+
Age of housing (dwellings) ⩾100 years		Age 35–64 years	
Renter (housing)		Age ⩾65 years	
Owner (housing)		African American	
Cats		White	
Dogs		Latino	+
Birds		Other race	

Risk factors that are positively (+) associated and negatively (−) associated with asthma and chronic respiratory illnesses at a significance level of $p \leqslant 0.05$.

Table 2 Distribution of asthma and chronic respiratory illnesses by selected variables

Variables	Asthma	95%CI	Chronic	95%CI
Sex				
Male	18.5 (106/573)	15 to 22	14.4 (82/568)	12 to 18
Female	31.4 (332/1057)	29 to 34	16.6 (175/1054)	14 to 19
Race				
African American	20.4 (161/790)	18 to 24	12.2 (96/786)	10 to 15
White	23.9 122/509)	20 to 28	18.4 (94/510)	15 to 22
Latino	50.1 (122/239)	45 to 58	17.9 (42/234)	13 to 23
Other race	30.2 (29/96)	21 to 40	22.9 (22/96)	15 to 33
Location				
Eastside	18.5 (80/433)	15 to 23	10.7 (48/445)	8 to 14
Westside	24 (157/654)	21 to 27	19.4 (151/777)	17 to 22
South Buffalo	40.5 (62/153)	33 to 49	11.2 (12/107)	6 to 19
Near West	46.1 (66/143)	38 to 55	15.2 (14/92)	9 to 24
Downtown	28.7 (75/261)	23 to 35	14.7 (32/218)	10 to 20

Data shown as percentages with numbers in parentheses. Prevalence shown for each independent variable. Asthma data based on the head of household's report of having been told by a healthcare provider that a person in their household had diagnosed asthma. Chronic respiratory illnesses data based on the analysis of persons with breathing problems in the preceding 12 months.

refused to participate in the study. The second stage entailed the distribution of 8 to 10 questionnaires per day, approaching households at different times of the day, especially early in the mornings and evenings. Upon arrival at the home, the surveyors introduced themselves, sought consent, and requested for the head of the household to conduct the survey.

The third stage entailed the evaluation of completed questionnaires by the survey team in consultation with the authors. Completed questionnaires were then submitted for entry into the computers. Three research assistants, trained and supervised by the authors, entered the data in Microsoft Excel worksheets. The final stage entailed calling a randomised sample of 200 households who had completed the questionnaires to validate some of their responses. Overall, the survey teams reported about a 2% to 5% refusal rate on particular days, that older people were more willing to participate than younger people, and that more households participated during the spring and summer seasons than winters. The survey of the community provided a good response rate of 82% of the targeted households.

Persons with asthma or chronic illnesses were identified among the individuals with respiratory problems based on questionnaire responses. The criterion for asthma diagnosis was based on the head of household's report of having been told by a healthcare provider that a person in their household had diagnosed asthma, while chronic illnesses were based on the analysis of persons with breathing problems in the preceding 12 months.

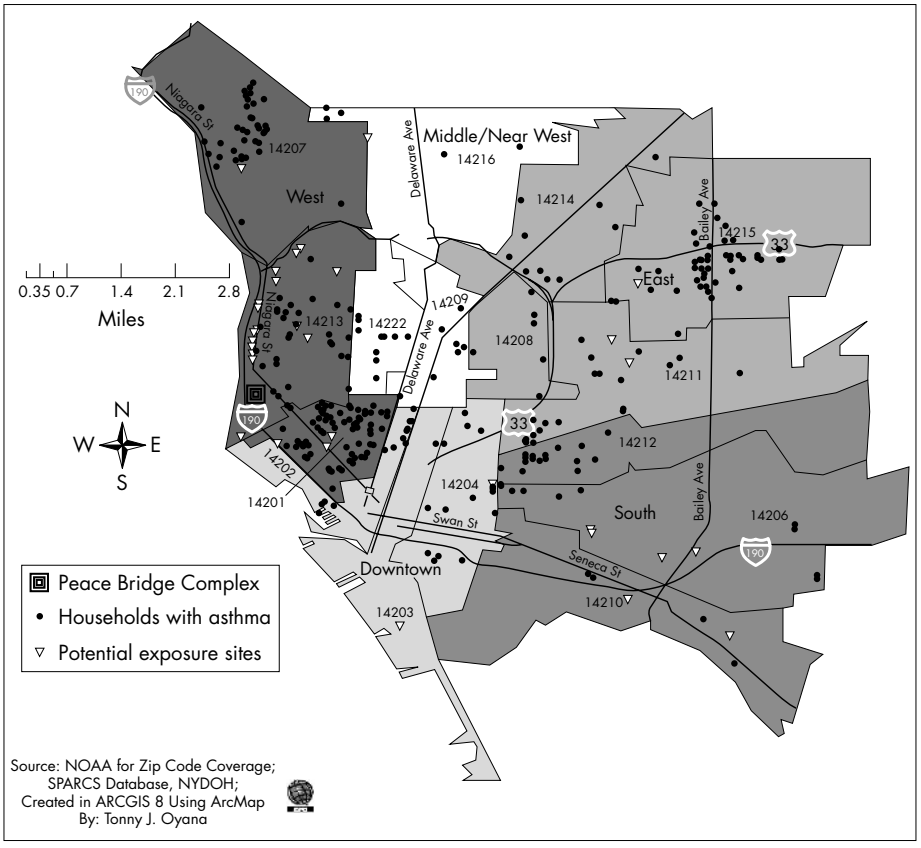

Figure 2 Spatial distribution of persons with asthma in relation to major roadways and potential exposure sites. Clustering of persons with asthma is evident in Buffalo's west side especially in zip codes 14201, 14207, and 14213 and along the major roadways and potential exposure sites. Fair distribution is evident in the east and south. Persons with asthma are sparsely distributed in the downtown and middle/near west locations.

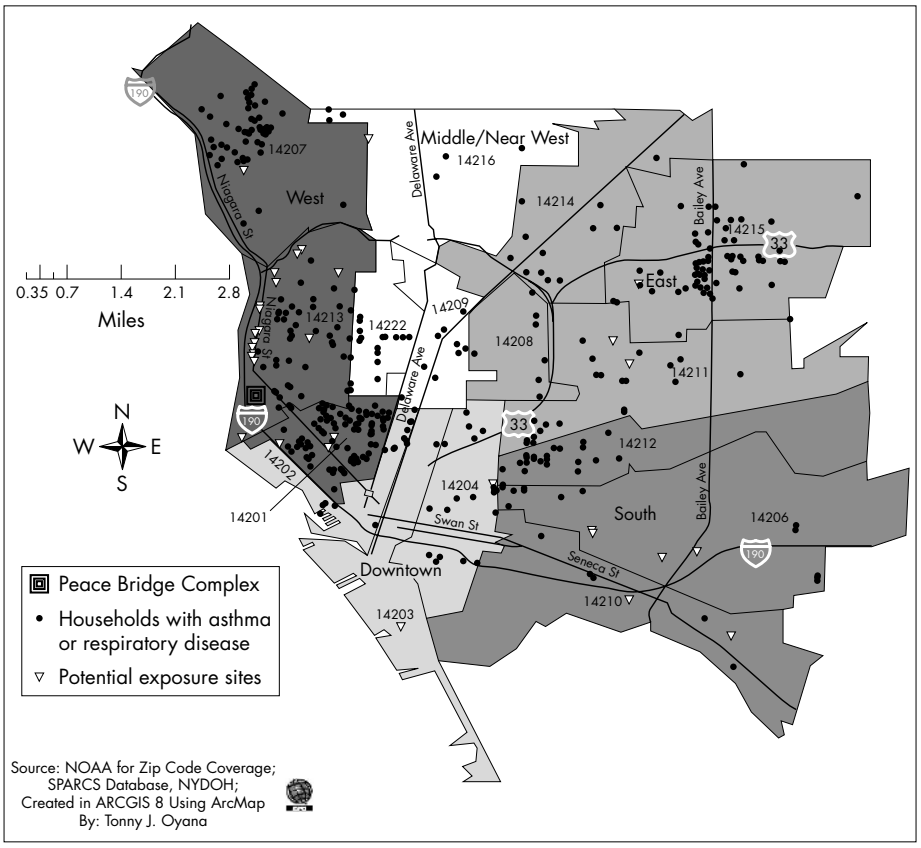

Figure 3 Spatial distribution of persons with asthma or chronic respiratory illnesses in relation to major roadways and potential exposure sites. A similar spatial pattern of distribution of persons with asthma or chronic respiratory illnesses is evident as described for figure 2.

Figure 1 presents the spatial distribution of surveyed households according to geographical regions in relation to major roadways and potential exposure sites. A sample ($n = 1277$) was available for multivariate analysis after coding variables of interest into dichotomous variables (yes, no). The sample size is reduced because of the coding process and missing values in some variables. Responses (yes, no) about persons with asthma and chronic respiratory illnesses had originally been compiled from a three part questionnaire used for the survey.

Multivariate analysis was conducted to assess potential relations between three mutually exclusive dependent variables and nine risk factors. Recent evidence reviewed in Oyana[28] about risk factors for asthma and chronic respiratory illnesses provided a rationale for defining these variables. Three mutually exclusive dependent variables (persons with asthma; persons with chronic respiratory illnesses; and a combination of persons with asthma or chronic respiratory illnesses) were used to evaluate risk factors for asthma and chronic illnesses. Nine risk factors (location, gender, age, household triggers, pets, smoking status, ethnicity/race, age of housing units, and educational status) yielded 32 subcategories (later referred to as variables/factors) from our study database as shown in table 1. The two categories of risk factors were analysed separately using a multivariate logistic regression model in three phases. The first phase entailed a preliminary assessment conducted to eliminate non-significant variables ($p>0.05$) from the general model, as well as to investigate potential confounders (race, gender, pets, education, and smoking) and interaction effects (age of housing×location, race×smoking, and age×smoking). The second phase entailed using a reduced model and the final phase of analysis produced our best model. A backward elimination strategy was preferred in all three phases of modelling. Residual analysis was conducted to evaluate our best model for test of lack of fit.

RESULTS

Multivariate logistic regression analysis of 32 factors found that only 20% (that is, three to six factors) of them were significantly associated with increased risk for asthma or chronic respiratory illnesses. Based on the general model used for analysis, persons with asthma comprised of 26.3% while the rest were non-asthma households. There were some observed interactions during the preliminary assessment phase and consequent models thereafter. Overall, the risk of persons with asthma and chronic respiratory illnesses is significantly ($p \leqslant 0.05$) high among children (6 to 17 years) and young adults (18 to 34 years) living in Buffalo's west side, or newer housing units, and of Latino ethnicity. A negative association was found among the male population in all three multivariate analyses conducted.

Table 2 presents the general distribution of asthma and chronic respiratory illnesses by selected variables. Most of the illnesses were observed among the female participants. Respondents reporting more than 36% of these illnesses resided in Buffalo's west side. Minority communities (African Americans and Latinos) are the most susceptible with more than 50% of self reported asthma and chronic respiratory illnesses.

Figure 2 gives the spatial distribution of persons with asthma in relation to major roadways and potential exposure sites. Clustering of persons with asthma is evident in Buffalo's west side especially in zip codes 14201, 14207, and 14213 and along the major roadways and potential exposure sites. Fair distribution is evident in the east and south of the study area. Persons with asthma are sparsely distributed in the downtown and middle/near west locations.

Table 3 Significant odd ratios (OR) of risk factors that were associated with asthma or chronic respiratory illnesses, Buffalo, New York

Variables	$OR = e^{\beta i}$	95%CI
Asthma*		
Westside	2.176	1.477 to 3.205
Male	0.533	0.355 to 0.799
Age of housing (1–24 years)	1.501	1.042 to 2.163
Age (6–17 years)	3.333	2.193 to 5.066
Age (18–34 years)	2.741	1.159 to 6.484
Latino	1.432	1.121 to 1.828
Chronic respiratory illnesses†		
Westside	1.685	1.246 to 2.280
Male	0.676	0.488 to 0.937
Age (6–17 years)	2.297	1.491 to 3.537
Asthma or chronic respiratory illnesses‡		
Westside	2.290	1.570 to 3.339
Male	0.548	0.422 to 0.711
Age of housing (1–24 years)	1.469	1.036 to 2.083
Age (6–17 years)	3.217	2.151 to 4.811
Age (18–34 years)	1.728	1.186 to 2.517
Latino	1.942	1.334 to 2.828

Likelihood ratio χ^2 test: *159.764, †20.980, and ‡129.528; analysis of risk factors is based on a multivariate logistic regression model ($p<0.000$); sample size (n = 1277); asthma data based on the head of household's report of having been told by a healthcare provider that a person in their household had diagnosed asthma; chronic respiratory illnesses data based on the analysis of persons with breathing problems in the preceding 12 months.

Figure 3 gives the spatial distribution of persons with asthma or chronic respiratory illnesses in relation to major roadways and potential exposure sites. A similar spatial pattern of distribution of persons with asthma or chronic respiratory illnesses was observed as described for figure 2. The maps show that Buffalo's west side has a high spatial concentration of persons with asthma and chronic respiratory illnesses compared with the other geographical regions (east, middle/near west, downtown, and the south).

Table 3 shows significant odd ratios (OR) of risk factors that were associated with asthma or chronic respiratory illnesses. Factors that were strongly associated with an increased risk for asthma among persons with asthma were residence in Buffalo's west side ($p<0.000$), age (that is, children of 6 to 17 years and young adults of 18 to 34 years ($p<0.000$)), and Latino ethnicity ($p<0.004$). Newer housing units were modestly associated with an increased risk for asthma ($p<0.029$) while there was a negative association among the male population.

Living in Buffalo's west side was strongly associated with an increased risk for chronic respiratory illnesses ($p<0.001$). There was a strong association among children ranging from 6 to 17 years ($p<0.000$). We found a negative association among the male population.

Residents living in Buffalo's west side ($p<0.000$), being of Latino ethnicity ($p<0.001$), and children of 6 to 17 ($p<0.000$); and adults of 18 to 34 years ($p<0.004$) were strongly associated with an increased risk for asthma or chronic respiratory illnesses. There was a modest association among newer housing units while a negative statistical association was found among the male population.

In a separate analysis of the nine risk factors, we observed that location, gender, age of housing, animal triggers, age, and race were identified as important risk factors for asthma. These results are consistent with our specific analysis of the 32 variables described earlier. However, the only main difference between the analyses of 9 and 32 variables is the statistical significance of animal triggers in the former. Also, further investigation of interaction effects using nine risk factors indicated that: (1) there was a statistically significant interaction between age of housing×location; (2) there was some interaction between race×smoking but the intercept was weak; and (3) there was no interaction between age×smoking. While the results in (1) and (2) may require additional analysis, we found that location, gender, age, and race were significant risk factors even after adjusting for age of housing, pets, moulds, animal trigger, and smoking.

DISCUSSION

The main findings of the study are: children aged 6 to 17 years and young adults 18 to 34 years, age of the dwellings (less than 24 years), Latino ethnicity, and location of the dwelling on Buffalo's west side are significantly ($p<0.05$) associated with increased risk of asthma and chronic

Key points

- A multivariate logistic regression model shows that the risk of persons with asthma and chronic respiratory illnesses is significantly ($p \leqslant 0.05$) high among children and young adults living in Buffalo's west side, newer housing units, and of Latino ethnicity;
- Children aged 6 to 17 years and young adults 18 to 34 years are significantly ($p<0.05$) associated with increased risk of asthma and chronic respiratory illnesses;
- Location, gender, age, and race were significant risk factors even after adjusting for age of housing, pets, moulds, animal trigger, and smoking.

Policy implications

- There is persuasive evidence supported by previous and current studies that residents living in close proximity to the US-Canada border crossing point have a major disease burden and attention should be focused on regulatory monitoring of air quality;
- This study provides much needed guidance to manage risk among people with asthma living near the US-Canada border crossing point;
- Incorporate health effects into trans-border transportation planning.

respiratory illnesses. These findings do confirm our hypothesis that a considerable risk of asthma and chronic respiratory illnesses exists particularly among certain groups living in specified locations of the study area. Findings of this study are also consistent with that of previous studies.[1–12] This study confirms that asthma and chronic respiratory illnesses remain a major health problem among Buffalo's west side residents living in close vicinity to the Peace Bridge Complex (PBC) and major roadways feeding it. The hardest hit residents are located downwind of the busiest US-Canada border crossing point, which harbours a major trade corridor for the (NAFTA partners serving the USA, Canada, and Mexico.

The main findings are not only useful to understand the characteristics of persons with asthma, but also in identifying risk factors for asthma and chronic respiratory illnesses in the study area. We will briefly examine the significance of these findings in detail below.

Residing on Buffalo's west side yields an increased risk for having asthma or a chronic respiratory disease, and this finding lends additional evidence suggesting that there may be a strong association between increased truck traffic from the PBC and the exacerbation of asthma and chronic respiratory illnesses in this community. This finding also suggests an increased risk of asthma or a breathing problem in persons residing in close proximity to the PBC and major roadways feeding it. The statistical significance, however, implies that there is an important health problem affecting the people residing on Buffalo's west side, and the problem is not improving; in actuality, it may be getting worse throughout the years with the asthma and bronchitis prevalence on the rise.[13] It is noteworthy however that, to date, no direct relation between inhaled diesel exhaust fumes and the development of asthma or other respiratory diseases have been reported[23]; additional studies are warranted to examine this issue further.

The age of the dwelling (newer housings) showed a statistically significant correlation with the presence of asthma or a respiratory disease among people residing on Buffalo's west side because of its potential contribution to increased morbidity and induction of asthma and chronic respiratory illnesses. It is possible that newer houses could be tightly constructed to preserve heat during winter seasons and might have a reduced air exchange system. Additionally, poor ventilation systems in newer housing units may increase amount of dust particles, dust mites, and fumes from indoor cooking with gas stoves, which may act as a trigger in asthmatic persons. However, cooking with gas stoves is widespread in all Buffalo communities.

People with Latino ethnicity were found to have an increased prevalence of asthma and this finding is consistent with current literature[30–36] and previous studies done in the area.[4 7 10] As Latino residents have the highest asthma rates and happen to live on Buffalo's west side this could be a confounder. Despite Latino ethnicity being a confounder, the link between selected respiratory system mortality and air quality problems in Buffalo's west side can be traced back to 1960s when this area was predominately populated by white people of European origin and African Americans.[37] Latinos are recent entrants who have migrated to this area mostly within the past decade. This finding might not fully explain why there is an increased risk for asthma and chronic respiratory illnesses which further lends support to our earlier explanation on current exacerbations and the genesis of asthma or chronic respiratory illnesses being a result of increased levels of inhaled diesel exhaust fumes.

We found a negative statistical association among the male population. This finding may be explained by our earlier findings,[7 10] which showed that females were more susceptible to asthma than males. The data also suggest that children and young adults have a higher respiratory disease burden than any other age groups. This particular finding is in agreement with some of the published work discussed earlier[1–6] and current literature on risk factors for asthma prevalence and chronic respiratory illnesses.[28 38] However, there were some study limitations that should be highlighted—for example, obesity—which were not evaluated in data collection; direct inspections of homes were not done; and underreporting of certain conditions could not be verified. This study does not, however, have any evidence to suggest that residents of any given community would be more likely to under-report some conditions than their peers in other neighbourhoods. There was also a demographic bias; for example, the reported race composition in comparison with the census data was different, and the dominance of older respondents was particularly skewed in the 30 to 65 year age group, which has implications for the findings of the study. This over-representation of certain groups is a potential bias. However, prevalence estimates were corrected to account for the selection bias. It is possible that the 2% to 5% households that did not participate in the survey might be different, but we have no obvious reason to believe that their asthma prevalence was any different from the other surveyed households.

In conclusion, the findings of this study have two important implications: (1) the three to six risk factors identified by this study are under the general umbrella of susceptibility factors, including genetic susceptibility, health status, residence and exposure history, and also lifestyle and activity might have some role in the induction and exacerbation of asthma; (2) there is an urgent need to characterise sources of environmental pollutants and exposures in Buffalo's west side, including outdoor and indoor sources. The characterisation process, if done in spatial and temporal terms, might provide further insights about potential relations between risk factors and environmental pollutants. While the major findings in this study have contributed to our understanding of how risk factors might influence asthma and chronic illnesses, further evaluation, including the need to correlate findings to air quality assessments, especially traffic related pollution, is warranted to definitively link asthma and environmental factors.

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